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HANDBOOK
OF
SYSTEMS EFFECTIVENESS MODELS

30 June 1972

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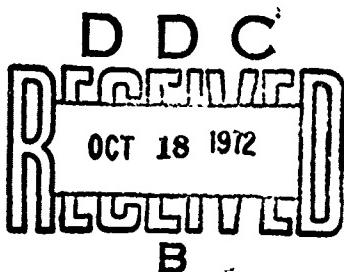
Prepared by Research Triangle Institute

Under Technical Direction of H. Greenstein

Systems Effectiveness Division, Code 4100

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13. ABSTRACT

Identifies and summarizes computer programs for modeling techniques currently used in effectiveness engineering. The programs employ a wide range of systems effectiveness techniques and convey the current variety in approaches used. They are summarized to assist engineers and analysts in the search for techniques to adapt for solution of their own application problems. The document will also serve as a basis for planning and future developments in effectiveness synthesis.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Effectiveness engineering						
Cost effectiveness						
Logistics support effectiveness						

FOREWORD

The purpose of this document is to identify and summarize for the reader computer programs for modeling techniques currently used in effectiveness engineering. Those computer programs employ a wide range of systems effectiveness techniques and convey the current variety in approaches used. They are summarized herein to assist engineers and analysts in their search for techniques to adapt for solution of their own application problems. It will also serve as a basis for planning and future developments in effectiveness synthesis.

Program categories were selected to be self-descriptive as to the effectiveness measure, attribute, technique or activity addressed. Most of the programs were not unique to a single category and Appendix A, Cross Index, lists other pertinent categories and additional key words. Some Integrated Logistic Support (ILS) programs, for instance, include modules which concern most of the remaining categories. In some instances these modules are summarized individually and in others, collectively. Coverage was determined by the information available and the integrity of the complex of programs.

The computer programs summarized herein are representative of the kinds or types available and are not intended to be comprehensive or all-inclusive. Contractural data, addresses, phone numbers, and names of cognizant individuals are included whenever available. An attempt was made to include only documented programs. Ownership and terms of purchase for no. -government programs were not generally available. Previous work on surveys and evaluations of programs is described in the following documents:

    a)   "Survey of Studies and Computer Programming Efforts for Reliability, Maintainability, and System Effectiveness," Report OEM 1, Office of the Director of Defense, Research and Engineering, September 1965 (AD-522 676).

b)   "Evaluation of Computer Programs for Systems Performance Effectiveness,"
     Volumes I and II, prepared by Research Triangle Institute for Naval
     Applied Science Laboratory, Contract N00140 66 C 0499, August 1967
     (AD-829 353L and AD-829 354L).

Each computer program is identified by the serial number in the lower right-
hand corner of each page. Bibliographic citations are listed by serial number and
are included as Appendix B.

ADMINISTRATIVE INFORMATION

TABLE OF CONTENTS

SECTION 1

COST ESTIMATING PROGRAMS

TITLE: Generalized Life Cycle Cost Model

LANGUAGE: FORTRAN IV

COMPUTER: B5500 (Time Share)

DATE OPERATIONAL: 1970

DESCRIPTION: This program aggregates costs per unit of equipment in three life
                    cycle phases: Research and Development (R&D), Investment, and
                    Operations and Maintenance (O&M). The Investment and O&M phases
                    are analyzed in more detail than the R&D phase. The program
                    provides the option of calculating a number of cost elements as
                    functions of other specific cost elements within the life cycle,
                    rather than aggregation from a lower level of estimation. The
                    output lists life-cycle costs by year and by phase, and cost
                    relationships by level of detail analyzed.

COMMENTS: A series of data collection sheets to assist in identifying data
                    requirements and a descriptive handbook are included in the source
                    referenced below. In large measure, this model represents an
                    enlargement and updating of a Computerized Cost Model for Electronic
                    Communications Equipment previously used by the developing agency,
                    the Army Electronics Command, Systems/Cost Analysis Office, Ft.
                    Monmouth, New Jersey.

SOURCE: A Generalized Life Cycle Cost Model for Electronic Equipment,
                    Booz-Allen Applied Research, Inc., Bethesda, Maryland, March 10,
                    1970 (AD-719 709).

TITLE: A Probabilistic Cost Estimating System Simulator (PROCESS)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 3300 with MSOS System, IBM 360/30, IBM 1620 II-D

DATE OPERATIONAL: Latest update - May 1970

DESCRIPTION: This computer simulation program provides flexible, iterative statistical modeling of cost and requirements uncertainties as a system analysis aid. An analytical system model is first constructed of independent and dependent uncertainty factors. This model provides the basic framework evaluation. A library of cost estimating relationships is provided in the program to evaluate the dependent factors based on input constant and independent factor data. A library of data distributions which are selectable as an approximation of the expected uncertainty of a cost or requirement is provided. The selected distribution is then bounded by high and low value estimates. This type of analysis is performed for each variable in the system model. A Monte Carlo iterative simulation routine is then performed on the data, the independent variable distributions are approximated and merged to obtain a total system uncertainty distribution. Dependent on data input modes, a single system may be estimated, competitive system design processes evaluated and analogous evaluations performed. The outputs are in the form of a tabular listing of the system distribution, a statistical summary of the data, and a line printer histogram plot of the output data.

COMMENTS:

SOURCE: Singer-Librascope, 808 Western Avenue, Glendale, California 91201, telephone (213) 245-8711. Contact G. F. Swygard and P. E. Roy, Jr.

TITLE:	System Parametric Allocation of Resources and Costs (SPARC)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65, FORTRAN G compiler

DATE OPERATIONAL: 1969

DESCRIPTION: The SPARC computer program was developed to aid in estimating the costs of proposed ICBM weapon systems. The SPARC cost model can be used for a variety of costing exercises. The primary use is intended to be as an aid to the preparation of preliminary technical development plans and contract formulation plans. A trained user of the program can reduce from months to days, the time required for a major cost analysis of a proposed weapon system. Other benefits provided by the use of the proposed basic system; reduction of the opportunity for human calculational error; reduction of clerical effort; and standardization of computations and presentation of results. Output is printed in formats conforming to the requirements of Air Force Systems Command Manual 173-1.

COMMENTS: The obvious disadvantages to the use of the SPARC program are the necessity of learning to use the program and the inflexibility inherent in conforming to the specific requirements of any computer program. The task of learning to use the program is intended to be facilitated by the source report below and a companion user's manual. The limitations imposed by the need to conform to data requirements, built-in costing factors, and input formats has been provided which provides nominal values of many of the required input parameters. Provisions have been made for the input override of the calculations of various components of the total cost model. This capability will allow the trained user to do much in tailoring the SPARC program to his individual needs.

SOURCE: J. W. Bond III: SPARC Computer Program, Aerospace Corporation, San Bernardino, California, TR-0059 (S6529)-1, March 1970, Air Force Report No. SAMSO-TR-70-234, prepared for Space and Missile Systems Organization, Air Force Systems Command, Los Angeles, California 90045 (AD-872 655).

5

TITLE: Computerized Cost Model (COCOM)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6400, IBM 360-65, IBM 370 series

DATE OPERATIONAL: 1968

DESCRIPTION: This is a large scale cost model for parametric estimating. It is capable of handling up to 500 or 1,000 Work Breakdown Structure (WBS) items depending upon model configuration. WBS items are estimated using internally stored equations with input formula coefficients. This model has seen extensive use on military and space contracts. Output includes cost by year for each WBS item or for any level of WBS desired. That is, cost may be computed at the fifth level with a printout showing cost only to the third level or fourth level, as designated by option. A summary output is also available. It provides total cost by WBS as well as the percentage that each cost item represents with respect to program phase (RDT&E, Investment, O&M, etc.) and to the total program, i.e., two percentages for each item. The program will also summarize a series of projects or weapon systems and provide the same by year output and percentage sensitivity information for the summary.

COMMENTS: This same source has a number of related programs which span all levels of system/mission detail and also provide integrated measures of cost effectiveness. This program (COCOM) is used in conjunction with the Integrated Logistic Support program MILSIM and the Availability program MILSAM for overall optimization of logistic decisions.

SOURCE: This program was developed by the Martin-Marietta Corporation Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

TITLE: SHIP

LANGUAGE: Time Share FORTRAN (Essentially FORTRAN IV)

COMPUTER: GE 635

DATE OPERATIONAL: April 1971

DESCRIPTION: The program accepts detailed annual operating costs and capital
                    costs for ships of different degrees of automation. It sums
                    capital and annual costs for the life cycle period, properly
                    allocating them according to constant subsidies, then calculates
                    total present worth of the costs. The data are then normalized
                    for equal ship productivity, and present worth is calculated.
                    The program will accomodate any number of ship concepts and prints
                    out the detailed life cycle data for each ship with both detailed
                    annual and life cycle costs displayed.

COMMENTS:

SOURCE: General Electric Company, P.O. Box 2500, Daytona Beach, Florida
                    32014, telephone (904) 258-3933. Contact Mrs. M. L. Currin or
                    F. J. Mayer.

TITLE:	Subsystem Operations Cost Model (SOCM III)
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360
DATE OPERATIONAL:	May 1969
DESCRIPTION:	This is an accounting type model that uses F-111 generated definitional equations to find recurring and non-recurring costs at the LRU/SRU level. It generates detailed cost estimates as input to overall life-cycle cost models. SOCM III consists of a cost model supported by a data file which may be the contractors automated support requirements and general logistics information file. The model has been designed to do a large amount of internal data manipulation after costs are computed. As a result, output is very flexible. The level of output detail can range from any individual LRU/SRU, combination thereof, to total force, ten-year input/cost ratios for any subsystem or system. The model can be used with maintainability parameters defined by design engineers or by operational experience. Advanced systems lacking this level of detail can be costed using CER's derived by SOCM III from analogous systems.
COMMENTS:	Refer to comments for Integrated Logistics Support program ORLA utilized by this same source.
SOURCE:	This Air Force sponsored program was developed by General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, Texas 76101, telephone (817) 732-4871. Contact Sam Abraham or Charles Hatfield, Operations Research and Support Requirements.

8

SECTION 2

INTEGRATED LOGISTIC SUPPORT PROGRAMS

TITLE:	TRANSIM IV
LANGUAGE:	FORTRAN
COMPUTER:	IBM 360/50 and up; GE 635; UNIVAC 1108; Control Data 6400 and up
DATE OPERATIONAL:	August 1971

DESCRIPTION: TRANSIM IV is a user-oriented management problem-solving tool for modeling and analyzing real-life problem situations by means of computer simulation. Because all aspects of the computer model and its simulated operation can be described in everyday terms on standard data forms, users of TRANSIM IV are not required to be familiar with computer operations or computer programming. Because TRANSIM IV is a general-purpose technique, its standard computer program is not modified from one problem to another. The entire description of the problem is set forth on the standard input data forms.

TRANSIM IV is suitable for modeling and problem situations which can be described in terms of the flow of "traffic" through a network of "operating elements." The traffic units might be trucks, ships, pallets, messages, invoices, man, fork trucks, dollars, documents, or tools; the operating elements would be the various system functions which process or utilize the traffic units. In the computer, the model operates just as does the aspect of system operation: number of items processed, queue lengths, service time distributions, man hours expended, etc. Alternative systems, procedures, policies, etc., are evaluated by making the appropriate changes to the basic model, "running" the model again in the computer, and comparing the results. Any input data may be specified in terms of probabilistic as well as deterministic times, quantities, etc. The output results will accurately reflect the effects of such variability.

COMMENTS: TRANSIM IV is an updated version of TRANSIM I, whose development was originally sponsored (1963-1966) by the Navy, U.S. Dept. of Commerce, and the Maritime Administration.

SOURCE: Project TRANSIM, School of Engineering and Applied Science, University of California, Los Angeles, California 90024. Telephone 213-825-1806.

TITLE: Systems Effectiveness Submodel (SES)

LANGUAGE: SIMSCRIPT 1.6

COMPUTER: IBM 360/91; CDS 3200

DATE OPERATIONAL: 1970

DESCRIPTION: SES simulates the operational environment in which an inventory
                    is to function by generating removals of specific parts from
                    aircraft, creating demands for replacements, sending parts to
                    repair facilities, simulating the return of repaired parts to
                    the base supply for re-issue, etc., over a specified period of
                    time. By maintaining a real-time history of each part of the
                    inventory, SES can measure the effectiveness of the total
                    inventory to support the squadron as it responds to a given
                    operational flight rchedule requirement. It therefore provides
                    the means for determining, for any specified support and opera-
                    tional concept, the following features: a. The probabilities
                    and distributions of delays for parts by aircraft system. b. An
                    approximation to the expected NORS rate. c. Periodic status
                    summaries of the repair/resupply pipeline, including number of
                    component removals, repair actions, shortages experienced, etc.
                    Output data are summaries by class of the parts. For example,
                    if the procurement cost of the parts is used as the differentiating
                    factor, a specific class of parts may consist of all those parts
                    costing over $5,000.00. On the other hand, parts may be classified
                    with reference to the particular aircraft systems with which they
                    are associated.

COMMENTS: This program is identified in WSAO Report R-70-3, dated 1 May 1970.

SOURCE: Naval Weapon Systems Analysis Office (WSAO), Marine Corps Air
                    Station, Quantico, Virginia 22134.

TITLE: General Operations and Logistics Simulation (GOALS)

LANGUAGE: GPSS

COMPUTER: IBM 360/65, 67, 75

DATE OPERATIONAL: November 1969

DESCRIPTION: This large scale simulation model is designed to evaluate and
                        measure the impact of various operational plans, logistics
                        concepts, costs, and resource levels (spares, personnel and
                        facilities) in the operation and support of a wing of aircraft
                        for periods up to 2 months duration. All of these elements can
                        be selectively altered to determine the effects on operational
                        effectiveness and life cycle costs of the weapon system. Both
                        organizational and field level maintenance tasks are simulated
                        to many levels of detail. Personnel are assigned to a shift by
                        special type and quantity based on selectable weekly schedules.
                        Base supply stock is replenished and all major details, such as
                        shipping costs are considered. The primary source of maintenance
                        data used for the B-52G baseline model development and validation
                        was the Air Force AFM 66-1 data collection system. GOALS outputs
                        a variety of reports. These include operational statistics such
                        as sortie/abort rates and operational ready rate; maintenance
                        reports of manhours per flight hour, downtimes, NORM and NORS;
                        supply reports of demands, cannibalizations, base repair times;
                        reliability reports; personnel availability reports; AGE, facility,
                        cost categories and life cycle costs.

COMMENTS: Documentation of GOALS has been transmitted to several Navy
                        agencies. The source below has an extensive collection of
                        related programs.

SOURCE: The Boeing Company. Contact Jack H. Kenny, Aerospace Group,
                        Kent, Washington, telephone (206) 655-8312. Also contact
                        C. S. Bartholomew, Boeing Computer Services Inc., P.O. Box 24346,
                        Seattle, Washington 98124.

TITLE: Reliability and Maintainability Effectiveness Models

LANGUAGE: FORTRAN

COMPUTER: 360/65, 67, 75

DATE OPERATIONAL: June 1970

DESCRIPTION: This is a program complex of multi-purpose models capable of
                    being used individually or integrated, depending on the nature
                    of the problem. The programs are designed to manage multiples
                    of variables, constraints, and parameters to provide realistic
                    design guidelines weighted against economics, logistics, and
                    operational factors. It can be used at any level of design from
                    system through piece part. Outputs can take on many forms
                    depending upon level of analysis and problem being evaluated.
                    In general, the outputs will provide decision criteria for:
                    (a) level of repair analyses, (b) level of maintenance analyses,
                    (c) spares optimizations, (d) redundancy effectiveness for
                    design (all forms), (e) economics trade analyses, (f) mission
                    effectiveness, and (g) reliability and maintainability allocations
                    for design.

COMMENTS: Some of the individual modular programs comprising this collection
                    are: Multi-state analysis (Markov Model) (MARKAP), Level of
                    Maintenance Analysis Program (LOMAP), Dynamic Programming Optimi-
                    zation (DYNPR), Apportionment Program Model (APPRO), Mission
                    Analysis Simulation Model (MAFTS).

SOURCE: Grumman Aerospace Corporation, Bethpage, Long Island, New York,
                    telephone (615) 575-7911. Contact V. H. Pellicione or
                    G. Friendenreich (Head), Systems Reliability and Maintainability.

TITLE: A Computer Programmed Mathematical Model for Maintainability
Prediction and System Support Requirements

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL:

DESCRIPTION: This program does all arithmetic computations involved in making
maintainability predictions and computes logistics support require-
ments for a complex weapon system. Outputs from this model are
based on the input and manipulation of the three prime determinants
of weapon system support requirements: reliability, maintainability,
and operational information. The model permits variation of these
parameters for trade-off analysis of various design configurations.
Some specific outputs are:

a.   Quantitative M_{ct} predictions at organizational and
field maintenance levels.
b.   Percent repairable by maintenance echelon.
c.   Failure distributions/deployed unit/unit time.
d.   Probable spares demend on maintenance and supply
systems.
e.   Stock level requirements/deployed unit.
f.   Depot repairables quantities.
g.   Workload data and active maintenance manpower
requirements.
h. A_i and A_o on an operational time and calendar time
basis.

COMMENTS: The same source has a number of related programs which span all
levels of system detail and also provide integrated measures of
cost effectiveness. This program, when coupled with costs (see
Cost Estimating program COCOM), may be used to justify the
selection of a maintenance concept and the resulting support
requirements.

SOURCE: This program was developed by the Martin-Marietta Corporation,
Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone
(305) 855-6100. Contact F. J. Denny.

TITLE:	Optimum Repair Level Analysis (ORLA)
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360
DATE OPERATIONAL:	September 1969

DESCRIPTION:

ORLA provides a systematic method for determining whether unserviceable equipment should be discarded, repaired locally, repaired in a mobile van, returned to a specialized depot repair activity or a combination of these alternatives used. The model will simultaneously analyze all specified items. The repair and discard costs are calculated at all repair levels for each item. A level of repair decision is selected for each item which results in the lowest possible cost for the entire equipment set. The model will accept up to three indentures in a set (example: top assembly, subassembly, module) for both mechanical and avionics items. The outputs are: (a) optimum repair level decisions, (b) costs associated with optimum and alternate repair level decisions, and (c) sensitivity of optimum repair level decisions to input parameters.

COMMENTS:

1.   This is an Air Force program. Input data include: fleet size, basing concept, flying program, item weight, failure types and frequencies, man-hours to repair; labor costs, parking and shipping costs, pipeline times; administrative, base and depot AGE, training and tech data costs. ORLA approaches the data uncertainty problem by considering several levels (i.e., a parametric analysis approach) of variable factors such as flying program and item cost.

2.   Source (1), below, has a complex of related programs such as SOCM III, SPAREM (both in this catalog) and others which utilize a large set of inputs in common. These inputs are obtained directly from the weapon systems automated support inventory and requirements data base in some instances.

SOURCE:

The program has been implemented by at least two prime contractors; (1) Advanced Logistics Dept. 501, Support Technology, McDonnell Douglas Corp., St. Louis, Missouri. Contact Howard L. Swain; (2) General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, Texas 76101, telephone (817) 732-4811. Contact Sam Abraham or George Cude.

TITLE: ILS

LANGUAGE: Extended Basic

COMPUTER: IBM 360

DATE OPERATIONAL: 1972

DESCRIPTION: This program prepares spares lists for electronic equipment.
The inputs are: parts MTBF's, parts counts (population density),
parts lists, and equipment designators. The output is a tabulated
spares requirements list by part numbers, for particular systems,
subsystems and equipments.

COMMENTS: The source given below has a number of related programs

SOURCE: Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634,
telephone (714) 871-3232. Contact E. W. Umlauf or V. D. Tomasule.

16

TITLE:	Military Essentiality Through Readiness Indices (METRI)
LANGUAGE:	FORTRAN
COMPUTER:	IBM 7090
DATE OPERATIONAL:	June 1965
DESCRIPTION:	The model was developed to permit calculation of a shipboard allowance list of repair parts. Its objective was to maximize the material readiness of the ship within a budget constraint. The approach was to structure in an engineering model the hierarchy from the ship's mission down through the system, subsystems, equipments, components, to the parts level in a successive dependency tree structure. The output of the calculation was a designation of the allowance list parts and quantities and a determination of the material readiness one could expect to achieve. The model was formulated using a single DD as the prototype structure.
COMMENTS:	
SOURCE:	Naval Supply Systems Command, Research and Development Division, (Code 0631B), Washington, D.C. 20390, telephone (202) 697-4561.

TITLE: Martin Integrated Logistics Support Model (MILSIM)

LANGUAGE: GPSS

COMPUTER: IBM 360

DATE OPERATIONAL:

DESCRIPTION: The purposes of this program are to simulate system support from the field through the depot level. The model consists of maintenance, supply and support services logic loops. The maintenance loop simulates corrective and scheduled maintenance at all levels above the organization. The supply loop takes spares requirements from all levels, provides and requisitions spares, and records spares statistics. The support services loop simulates the provision of peripheral services such as transportation, facilities maintenance and personnel support functions.

COMMENTS: The same source has a number of related programs which span all levels of system detail and also provide integrated measures of cost effectiveness. This program (MILSIM) used in conjunction with a Cost Estimating program (see COCOM) and a mission oriented Availability program (see MILSAM) simulates operation and support from the organization through the depot and produces life cycle costs.

SOURCE: This program was developed by the Martin-Marietta Corporation, Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

TITLE:	Spares Provisioning and Requirement Evaluation Model (SPAREM)

TITLE: Spares Provisioning and Requirement Evaluation Model (SPAREM)

LANGUAGE: SIM3CRIPT

COMPUTER: CDC 6600, IBM 360

DATE OPERATIONAL: 1970 (CDC), 1969 (IBM)

DESCRIPTION: This program provides an evaluation of inventory effectiveness in terms of such measures as flights missed, Not Operationally Ready Supply (NORS) rate, and backorder days. It can be used to establish the relative merits of various logistics policies (e.g., spares management procedures and repair policies) and to evaluate their concommitant impact on aircraft availability. Cannibalization, expedited maintenance, and priority resupply are simulated over several months operation in order to depict realistic wing activation problems. Input data for each LRU and module include removal rate, NRTS rate, shop repair time, order and shipping times from depot, and initial inventory levels. The cycle times for repair and resupply are determined by sampling input distributions. Outputs are NORS rate, OR rate, shortages, backorder days, LRU and module cannibalization, flights on-schedule/cancelled/rescheduled.

COMMENTS: Refer to comments for Integrated Logistics Support program ORLA, utilized by this same source.

SOURCE: This program was developed by General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, Texas 76101, telephone (817) 732-4811. Contact W. M. Faucett or R. D. Gilbert, Operations Research & Support Requirements.

19

TITLE:	Pipeline Spares Cost Model (NORSPARE)
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360/65
DATE OPERATIONAL:	1969
DESCRIPTION:	The NORSPARE model utilizes a minimum-cost method of allocating the total number of each weapon system's components required to satisfy the pipeline requirement subject to the constraints of a specified Not Operationally Ready-Supply (NORS) rate. Allocation is made with a simultaneous consideration of the following input data: the specified NORS rate, number of aircraft, sorties per aircraft per day, flight hours per sortie, spares demand rates (units per flight hour); pipeline times, and unit costs. The output is composed of the federal stock number and/or part number of the Line Replaceable Unit (LRU), the LRU nomenclature, and the pipeline spares cost by each of the major pipeline spare categories. These categories, condemned, NRTS, and repair are shown along with a total cost for the LRU. A summary is also compiled which illustrates pipeline spares costs as a function of federal stock class.
COMMENTS:	This same source has other, related programs which are modularized toward various needs for information such as: Source Model (operational capability analysis), Maintenance Break Rate Program, Maintenance Regeneration Program, Direct and Indirect Maintenance Manpower Program, Maintenance and Support Manning Program, Replenishment Spares Cost Model, and Computerized AGE Requirements Program.
SOURCE:	Northrop Corporation, Aircraft Division, 3901 West Broadway, Hawthorne, California 90250, telephone (213) 675-4611. Contact D. D. Gregor.

<u>TITLE</u>:	Inventory Planning Model
<u>LANGUAGE</u>:	FORTRAN IV
<u>COMPUTER</u>:	
<u>DATE OPERATIONAL</u>:	October 1970
<u>DESCRIPTION</u>:	This program optimizes a spare parts inventory at two levels of assembly (weapons replaceable assembly and shop replaceable assembly). Inventory selection can be constrained by either ~st or backorder days. The simple Poisson or compound Poisson ~istribution can be used. If the compound Poisson is used, a variance to mean ratio input for each candidate part is required.
<u>COMMENTS</u>:	
<u>SOURCE</u>:	Contact G. C. Henry, Operations, Naval Air Systems Command, (Code 4013), Columbia Pike Office Building, Arlington, Virginia 20309

TITLE: An Economic Equipment Replacement Model (ERM)

LANGUAGE: SIMSCRIPT 1.5

COMPUTER: IBM 7094

DATE OPERATIONAL: September 1968

DESCRIPTION: This equipment replacement model is based on economic life
                   theory. Consideration is given to repair cost in order to
                   develop an operational decision rule. The decision rule is
                   based on a maximum one-time repair cost limit. Application
                   of this decision rule takes advantage of repair cost infor-
                   mation in order to improve on a policy of automatic replacement
                   at the end of economic life calculated on the basis of histor-
                   ical data.

COMMENTS:

SOURCE: Naval Seabee Systems Engineering Office (Code 15B), Fort
                   Hueneme, California 93043, telephone: Commercial (805) 982-
                   4942, Autovon 898-3300 X4942. Documentation exists for this
                   program.

TITLE: Carrier Aircraft Squadron Effectiveness Evaluation (CASEE)

LANGUAGE: GPSS-360/Norden

COMPUTER: IBM 360/370

DATE OPERATIONAL: July 1970

DESCRIPTION: The CASEE simulation model has been developed as a systems
                    analysis tool for relating the operational effectiveness of
                    carrier-based aircraft to aircraft reliability and maintain-
                    ability design characteristics as well as to carrier support
                    resources in terms of personnel, procedures, support equipment,
                    spares and space. By examining the model with different assump-
                    tions in respect to these system parameters, quantitative trade-
                    off data can be obtained for systems analysis and as backup in
                    decision making. The present version of CASEE is structured
                    around the A-6A Intruder; however, it has been designed to be
                    adaptable to all other carrier-based aircraft types, and also
                    to be expandable to include an entire carrier air wing. The
                    simulation procedures standard GPSS output statistics and also
                    a summary report tailored to suit the user's needs. Typical
                    outputs are: aircraft readiness data, flight data, maintenance
                    summaries, manpower utilization and spares activity.

COMMENTS: This work was sponsored by the Naval Air Systems Command under
                    Contract No. N00019-69-C-0040.

SOURCE: Seidler, S. W.: The CASEE (Carrier Aircraft Squadron Effective-
                    ness Evaluation) Simulation Model. Prepared by Norden Division,
                    United Aircraft Corporation for the Naval Air Systems Command,
                    Washington, D.C., July 1970, 126pp. (AD-875 131).

TITLE:	Budget Allocation Procedures for Naval Aircraft Ground Support Equipment
LANGUAGE:	Inventory; Allocation
COMPUTER:	CDC 6600; UNIVAC 494
DATE OPERATIONAL:	June 1971
DESCRIPTION:	The method is intended to be used in determining replenishment quantities for a specified segment of aviation ground support equipment managed at the Navy Aviation Supply Office. The model incorporates a budget constraint and has as its objective function the minimization of the total of time-weighted shortages supply system-wide. The method includes a Bayesian forecasting procedure as well as considering the elements of procurement leadtime, repair cycle time and attrition, in the replenishment quantity determination.
COMMENTS:	
SOURCE:	Naval Supply Systems Command, Research and Development Division (Code 0631B), Washington, D.C. 20390, telephone (202) 697-4561.

SECTION 3

EFFECTIVENESS PROGRAMS

TITLE:	System Effectiveness Simulation Model

LANGUAGE:. FORTRAN IV

COMPUTER: IBM 7094

DATE OPERATIONAL: June 1967

DESCRIPTION: A straightforward extension of the basic WSEIAC model permits a partition of the capability of the system into that which is contributed by the hardware system and that which is attributable to the human factor. When the functional relationships of the various subsystems have been ascertained, the computer program will accept at subsystem level the quantitatively specified (or demonstrated) MTBF, MTTR, MDT, individual estimates of probability of use for specified system states, and the parameters of the associated capability distributions for both the personnel and hardware subsystems. The computer program will accept information regarding the uncertainty and it will automatically generate sampling distributions of the systems effectiveness for each subsystem and for the overall system.

A potential user may wish to obtain some of the following types of information as output provided that he can furnish the appropriate inputs: (a) A point estimate for each subsystem effectiveness and for the overall system effectiveness for each mission interval and/or for the whole mission. (b) The relative impact on these effectivenesses when uncertainty (variability) in specified combinations of the system attributes. (c) The effect of introducing repairability. (d) Trade-off analysis among system attributes.

COMMENTS: This appears to be a quite flexible and potentially useful program. N. A. Engler, University of Dayton Research Institute, telephone 229-3921 is also familiar with the Air Force Aeronautical Systems Division (ASD) under contract AF33(615)2707. A report has been published (AD-863 449).

SOURCE: Balachandean, V. and Gephart, L. S. (University of Dayton): A Computerized Approach to Simulating System Effectiveness. Proceedings 1971 Annual Symposium on Reliability, Washington, D.C., January 12, 13, 14, 1971, pp. 245-253.

TITLE:	System Effectivity Calculation and Analysis (SECAN)
LANGUAGE:	FORTRAN IV
COMPUTER:	
DATE OPERATIONAL:	
DESCRIPTION:	This consists of two program modules, RETURN AND EFFCTV. RETURN uses Monte-Carlo simulation to determine the value return distribution function. Input consists of the mission times at which the system state is reviewed and pay allocated accordingly, the pay matrix, and component failure rates. Various performance constraints or success-path criteria are also accepted to be used for pay allocation in special situations. The output of RETURN is a curve which gives the probability of achieving at least a specified value return, e.g., hours of data or incentive fee dollars. The expected return and standard deviation are calculated to show whether system performance can be expected to be satisfactory, and how much margin exists above minimum requirements. EFFCTV performs a system level Markovian value return analysis. The values of given combinations of failed and non-failed system functions are inputs together with failure-rates for the system components. The program evaluates the system state probabilities and performance loss functions, and then determines the expected fraction of full system capability and the cumulative value return as functions of mission time. Questions answered by EFFCTV are: What fraction of full system capability will be available at mission time t? How much returns (hours of data, incentive fee, etc.) have been cumulated from the mission at time t?
COMMENTS:	This is part of a collection of related program modules collectively termed Reliability Engineering and Analysis using Computerized Techniques (REACT) developed by the reference source.
SOURCE:	Western Development Laboratories Division of Philco-Ford Corporation, 3939 Fabian Way, Palo Alto, California 94303, telephone (415) 326-4350, contact T. Turner and J. M. Legg.

28

TITLE: ASW Ship Effectiveness

LANGUAGE: FORTRAN IV, STRAP

COMPUTER: IBM 7030 (STRETCH)

DATE OPERATIONAL: February 1968

DESCRIPTION: The ASW Ship Effectiveness Program is a computer simulation
                      designed for studying the relative effectiveness of existing
                      or proposed ASW surface ship systems, subsystems, weapons
                      and tactics under likely environmental and tactical condi-
                      tions. Program input flexibility is sufficient to describe
                      the salient performance characteristics of both surface and
                      subsurface systems, and wide latitude exists for specifying
                      operational concepts and tactical doctrine.

COMMENTS:

SOURCE: Current Mathematical Models (For Digital Computers). Naval
                      Weapons Laboratory (NWL), Dahlgren, Virginia, NWL TR-2390,
                      August 19:0, p. 42 (AD-872 919L).

                      Contact R. L. Kulp, D. R. Snyder, L. E. Perkins, or R. T. Bevan
                      at NWL.

TITLE: Squadron Performance Effectiveness Analytic Representation
                    (Flight Model), (SPEAR (FLITE))

LANGUAGE: FORTRAN

COMPUTER: CDC 3200

DATE OPERATIONAL: June 1967

DESCRIPTION: The FLITE model analyzes the mission effectiveness of an
                    aircraft. Several phases of a mission can be studied in
                    terms of degraded mode probability states of required
                    equipments. It is a self-contained segment of SPEAR.

COMMENTS:

SOURCE: Naval Air Development Center, (Code SAED/SR), Johnsville,
                    Warminster, Pennsylvania 18974.

SECTION 4

AVAILABILITY PROGRAMS

TITLE: Generalized Effectiveness Methodology (GEM)

LANGUAGE: GEM Language

COMPUTER: CDC 6600

DATE OPERATIONAL: August 1966

DESCRIPTION: The Generalized Effectiveness Methodology (GEM) is a user-oriented computer program for computing one or more of a set of system statistics such as reliability, availability, mean up time, mean down time, effective failure and repair rates, restore time distributions and repairmen utilization. The inputs required are the system model and data in the form of parameters of distributions of times to failure and times to repair for the elementary components of the system. The system model essentially incl des the reliability configuration of the system, a set of system failure definitions, and logistic information in terms of repair crews, spares pools and priorities. The system model may include any reliability structure. For systems without repair, the elementary components can be characterized by any one of five distributions of times to failure: exponential, Weibull, gamma, log normal, and truncated normal distributions. For systems with repair, distributions of times to failure, repair, or replacement for the elementary components are assumed to be exponential only. A user-oriented high level source language is used. Inputs written in the GEM Language are used by the GEM Compiler to generate a FORTRAN program. Depending on the problem, solutions by GEM are obtained either by combinatorial methods or b· solving a set of linear differential equations describing the system state probabilities, or both. Answers are given in the forms of tables and plots.

COMMENTS: The original GEM program was updated aperiodically. Documents published in 1971 include the Capability Summary (TD 131), User's Manual (TD 114), Reference Manual (TD 115), and Mathematics Library Manual (TD 116).

SOURCE: For documents or further information, contact Naval Electronics Laboratory Center (Code 4100), San Diego, California; or Naval Ships Engineering Center (Code 6102C), Hyattsville, Maryland.

TITLE: Reliability and Availability Program (RAP)

LANGUAGE: PL/I And Assembly Language

COMPUTER: IBM 360

DATE OPERATIONAL: 1971

DESCRIPTION: RAP is for modeling and evaluating systems with respect to a
                  selection of three statistics: reliability, availability, and
                  transition rates between system states. The program is appli-
                  cable to systems with repair, active and standby redundancies,
                  multiple operational modes, and multiphase missions. The
                  elementary items of the system are assumed to have times to
                  failure and repair which are described by exponential distri-
                  butions with constant parameters. Essentially, the inputs to
                  RAP include reliability/maintainability/availability model of
                  the system, item failure and repair rates, and system failure
                  criteria or mission requirements. The model is described in
                  terms of blocks and repair facilities, where a block is a group
                  of identical elementary items or equipments required to perform
                  a system function, while a repair facility is a unit of repair
                  capability to which equipments from one or more blocks may be
                  assigned for repair according to ordered priorities. For the
                  elementary items within each block, RAP offers a choice of two
                  item models which effectively allows one to consider either one
                  or two levels of failure for a given equipment.

COMMENTS: RAP is an updated version of a program called MINI-GEM which
                  was created by extracting a subset of the capabilities from
                  the Generalized Effectiveness Methodology (GEM) program and
                  introducing some simplifications and flexibility. Although
                  both RAP and GEM perform basically the same functions, they do
                  differ in a number of features. These include the input/output
                  formats, program size and machine requirements, as well as the
                  types of systems modeled and the statistics evaluated. (See
                  availability program GEM.) A RAP User's Manual, dated
                  September 1971, is available.

SOURCE: RAP was originated by the System Analysis Branch (Code 6112),
                  Ship Concept Design Division, Naval Ships Engineering Center,
                  Hyattsville, Maryland 20782.

34

TITLE: MAXISIM/TIGER

LANGUAGE: FORTRAN EXTENDED

COMPUTER: CDC 6600, FTN V3.0

DATE OPERATIONAL: 1971

DESCRIPTION: MAXISIM/TIGER is a monte carlo simulation program for estimating
                      reliability and availability of systems with multiphase missions
                      and allowable downtimes. It is generally applicable for systems
                      with series-parallel or m-out-of-n reliability configurations.
                      Elementary items, of the system are assumed to have times to
                      failure and repair described by exponential distributions with
                      constant parameters. The inputs required by the program are
                      essentially the system reliability configuration; mean times to
                      failure and repair, and utilization factors of the equipments;
                      and mission abort criteria. The mission abort criteria are
                      given in terms of the set of allowable downtimes: T_1 is the
                      negligible downtime, T_2 the allowable sustained downtime, and
                      T_3 the cumulative downtime. With this set of criteria, a
                      mission is aborted if either T_2 or T_3 is exceeded by the system
                      downtime. The program offers a number of features or options,
                      including consideration of standby redundancy (at equipment
                      level), choice of repair or no repair during a mission phase,
                      alternate phase schemes, and alternate computer output print-
                      outs.

COMMENTS: The program is basically similar to the MAXISIM/TIGER (See
                      SIM-3). A MAXISIM/TIGER User's Manual, dated December 1971,
                      is available.

SOURCE: MAXISIM/TIGER was generated by the System Analysis Branch
                      (Code 6112), Ship Concept Division, Naval Ships Engineering
                      Center, Hyattsville, Maryland 20782.

TITLE:	Precedence List Reliability - Version 3 (PLR-3)
LANGUAGE:	FORTRAN
COMPUTER:	CDC 3200, IBM 360
DATE OPERATIONAL:	1966

DESCRIPTION: The PLR-3 program was designed to calculate reliability and availability for systems the reliability configurations of which may include series, parallel, and bridge type structures. The program accepts as input a reliability network of the system described by a precedence list, data in the form of equipment failure and repair rates, and time points for which the system reliability and/or availability functions are to be evaluated. It is assumed that all equipment times to failure and repair are exponentially distributed with constant parameters. The system availability is calculated under the assumption of no repair limitations or constraints, while reliability is calculated for systems without repair only. In addition, PLR-3 also performs reliability and availability allocations for serial systems using an equal apportionment method.

COMMENTS: The PLR program was developed for the Navy by the Fundamental Methods Associates, Inc. The original version of the program was called PLR-1, which was updated and became known as PLR-2. The PLR-3 program is the result of the last update. Both PLR-1 and PLR-2 are described in a document entitled "Precedence List Reliability Calculations," October, 1966. PLR-3 was described in another document entitled "Calculation of System Reliability and Availability as a Function of Time by Precedence List Methods," December 1966.

SOURCE: Naval Electronics Laboratory Center (Code 4100), San Diego, California.

TITLE:	Mean Up and Down Time Program

TITLE: Mean Up and Down Time Program

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: 1971

DESCRIPTION: Two important measures of system effectiveness are Mean Up-Time (MUT) and Mean Down-Time (MDT). MUT is defined as the average time (in the steady state) the system spends in system up-states after it returns from a system down-state due to completion of a repair. MDT is defined as the average time (in the steady state) the system spends in the system down-states after it enters into one of them due to occurrence of some failure. The concept of viewing the Markov process of a Markovian system as an imbedded Markov chain together with exponential holding time at each system state is employed to simplify the computation. The output is the MUT and MDT, with the input being a partition of the transition rate matrix.

COMMENTS: The listing is in the reference noted below, along with the theoretical development of the method.

SOURCE: Lee, C. T. H. and Duhman, A. (Dynamics Research Corporation, Wilmington, Massachusetts 01887): New Results in Effectiveness Prediction for Markovian Systems. Proceedings 1970 Annual Symposium on Reliability, Washington, D.C., February 3, 4, 5, 1970, pp 410-419.

TITLE: Ship Propulsion Concept Formulation Reliability and
Availability Program

LANGUAGE: FORTRAN

COMPUTER: IBM 360/40

DATE OPERATIONAL: 1968

DESCRIPTION: This program was designed to evaluate ships propulsion plants
at the concept formulation stage of development. It generates
data for computing reliability, reliability with repair, and
availability numerics. The program is Monte-Carlo simulation
wherein times-to-failure and times-to-repair are exponentially
distributed. Input failure and repair data can be in the form
of a table, actual distribution or just a mean value for each
equipment. Each phase of the mission may be assigned specific
constraints, such as minimum downtime, maximum accumulated
downtime, configuration and required equipments to be opera-
tional. For each phase, the system is described in the usual
reliability block diagram. This consists of a series of blocks,
each of which contains parallel branches with equipments in
series (or single equipments). The program handles active
redundancy only - not standby.

COMMENTS: Program listings are in the source reference below.

SOURCE: Langley, Harvey L.: Ship Propulsion Concept Formulation: Reli-
ability and Availability Simulation, Naval Ship Research and
Development Laboratory, Annapolis, Maryland, May 1969, 82 pp.
(AD 853-075).

TITLE:	General Availability Program (GAP)
LANGUAGE:	FORTRAN V
COMPUTER:	UNIVAC 1108, EXEC 8
DATE OPERATIONAL:	1970
DESCRIPTION:	This program performs an availability analysis of a system. Availability of a system is the proportion of time that the system is in acceptable states. This system measure is a function of the mission to be accomplished and is also a function of such mission elements as the system replenishment method, system supply, system production schedules, and system reliability. The system involved in the analysis can be defined at any level of complexity for a component or module all the way up to a large system. The method of analysis used in the program is Monte Carlo. The simulation approach is used because of the inadequacy of closed form methods in considering complexities such as introduced by non-exponential survival functions, non-homogeneous system populations, production constraints, and complex replenishment methods.
COMMENTS:	Source below has in its scientific computational library a series of computer programs to perform system effectiveness and related engineering analysis.
SOURCE:	Lockheed Missiles and Space Company, Sunnyvale, California, telephone (408) 743-2486. Contact R. L. Ramsey or W. L. Finch.

TITLE:	Reliability and Availability Analysis Program
LANGUAGE:	Basic
COMPUTER:	GE 635, CDC 6400, POP-10
DATE OPERATIONAL:	June 1970
DESCRIPTION:	A computer program was developed for the time sharing which enables one to compute the reliability of a system composed of up to 100 elements and up to 50 strings of elements. Data input consists of failure rates or MTBF's or probability of successful operation, times of operation, and K factors for each of the elements, and a description of how the elements are configured in the reliability model. At present, active partial redundancy, standby redundancy, and series and series-parallel configurations can be handled by the program in any combination. It is assumed that all elements have exponential failure-time densities. The first step in performing the reliability analysis of a system is to generate the reliability block diagram to identify the various string configurations used in the system. Next, obtain failure rates and operate times for each of the elements. The failure rates may be modified by a single K factor or by separate K factors. These data are then entered via the terminal for the program computation. Outputs are reliability and availability values for each unit, each string configuration and system.
COMMENTS:	Source below has a number of related programs.
SOURCE:	ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401, telephone (301) 268-4100. Contact H. Dagen.

TITLE:	Mechanized Assessment of System Reliability (MASER)
LANGUAGE:	FORTRAN IV
COMPUTER:	GE 615 (time share)
DATE OPERATIONAL:	

DESCRIPTION: This consists of two program modules. One module, named FT5, computes reliability for series, parallel and standby with or without command switching. Input consists of mission phase, environmental K-factors, duty cycles and system indenture structure. A printer plot routine is included to graphically display reliability vs. time. The program automatically adjusts to provide the most meaningful output should some inputs be missing. This is extensively used to update reliability estimates. A second module, named S&A, computes availability, reliability and aggregates costs for three levels of indenture. Both the initial and recurring costs of implementing and maintaining the sub-systems under study are displayed. Since at times certain hardware groupings, called segments, appear in many areas, the output results may be stored for retrieval and use in subsequent calculations.

COMMENTS: This is part of a collection of related program modules collectively termed Reliability Engineering and Analysis Using Computerized Techniques (REACT) developed by the source below.

SOURCE: Western Development Laboratories Division of Philco-Ford Corporation, 3939 Fabian Way, Palo Alto, California 94303, telephone (415) 326-4350. Contact T. Turner or J. M. Legg.

TITLE:	Reliability and Maintainability Calculations for System Availability
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360/30
DATE OPERATIONAL:	September 1969

DESCRIPTION: This is a three program system. Program One calculates failure rates and repair rates for each functional block in the system. The rates are determined using actual data values. Program Two calculates subsystem availability for various groups of functional blocks. The SEIAC approach is used to calculate subsystem availability at the end of each mission phase. Program Three summarizes the output from Program Two to calculate system availability at the beginning and end of each mission phase.

Program One produces only punched data for use in Program Two. Program Two prints the subsystem availability for the subsystem states and punched data for use in Program Three. Program Three prints system availability at the beginning and end of each mission phase.

COMMENTS: Source below has a number of related programs.

SOURCE: This program was developed by the ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401, telephone (301) 268-4100, for the Naval Weapons Quality Assurance Office under contract N00600-69-C-0317. Contact H. J. Kennedy.

SECTION 5

RELIABILITY PROGRAMS

TITLE: Scenario Simulation Program, Version 3 (SIM-3)

LANGUAGE: FORTRAN

COMPUTER: CDC 3200, 3300, IBM 360

DATE OPERATIONAL: 1969

DESCRIPTION: This program was designed for computing mission reliability of
                      a system with allowable downtimes. The mission reliability
                      being computed is the probability that the mission's equipment
                      requirements, which may be different for different phases of a
                      mission, will be met by the system throughout the mission.
                      This program is applicable for systems with reliability config-
                      urations which contain series-parallel or m-out-of-n structures;
                      i.e., the system consists of a number of subsystems connected
                      in series, with each subsystem being described by a parallel or
                      m-out-of-n structure. The elementary items of the system are
                      called equipments, for which the times to failure and repair
                      are assumed to have exponential distributions with constant
                      parameters. All equipments of the system are assumed
                      independent, and the system is assumed to have no repair
                      limitations or constraints. The inputs are a reliability
                      configuration of the system for each phase of the mission;
                      equipment mean times to failure and repair: mission abort
                      criteria; and a utilization factor for each equipment. For
                      each computer run, mission success or abort is determined
                      using a monte carlo sampling procedure. The mission reliability
                      is then given by the ratio x/N, where N is the total number of
                      computer runs, and x is the number of runs for which the
                      simulated mission is successful. The outputs may also include
                      all simulated events (equipment failures and mission abort)
                      and the time of their occurrence. The ratio x/N is an estimate
                      of the true mission reliability. The confidence level associ-
                      ated with this estimate is a function of N, the number of
                      computer runs.

COMMENTS: The first and second versions of the Scenario Simulation Program
                      were called SIM-1 and SIM-2, both of which were superceded by
                      SIM-3. All three versions were generated by Naval Applied
                      Science Laboratory (NASL). SIM-3 has been described in
                      Appendix J of the NASL final report on Lab Project 920-72-16.

SOURCE: Naval Electronics Laboratory Center (Code 4100), San Diego,
                      California.

TITLE:	Programmed Analysis and Calculation of Equipment Reliability (PACER)
LANGUAGE:	FORTRAN IV
COMPUTER:	Most machines 32K (bit) or larger
DATE OPERATIONAL:	
DESCRIPTION:	PACER calculates the failure-rate of electronic parts and equipment as a function of applied electrical and temperature stress. Input to PACER can range from the detailed failure-modes-and-effects data to the bare minimum of a simple parts list. This program will read a company standard, MIL-HDBK-217A, or a job-oriented parts reliability data library card deck, which consists of the part identity, base failure-rate, and failures mode distribution. In addition, electrical/temperature stress coefficients, minimum failure rate, number of leads, observed average stress, electrical rating, MIL Spec number, part class code, application K-factors, and the limits of failure-rate model applicability are usually supplied. The program automatically recognizes the detail of the input and adjusts the output accordingly. All input information, regardless of detail, is supplied in the same format, using the same coding sheets. This removes the need for special data arrangement for the various analyses and keeps the process simple. Major outputs are: (a) part failure-rates displayed in report format, (b) assembly/circuit total and FMEA failure-rate summaries, (c) inventory count by part type used, (d) total count of weldable/solderable connections per circuit, (e) average electrical stress by part type, (f) library data summary, and (g) logistics spare parts requirements.
COMMENTS:	This is part of a collection of related program modules collectively termed Reliability Engineering and Analysis using Computerized Techniques (REACT) developed by the referenced source. Copies of the PACER program are sent to all requestors.
SOURCE:	Western Development Laboratories Division of Philco-Ford Corporation, 3939 Fabian Way, Palo Alto, California 94303, telephone (415) 326-4350. Contact T. Turner or J. M. Legg.

TITLE:	Bounds for Reliability Analysis of Paths and Cuts
LANGUAGE:	Dialect of FORTRAN II
COMPUTER:	IBM 360
DATE OPERATIONAL:	1969

DESCRIPTION: This program provides bounds for system reliability. The algorithms are based on the concepts of success paths and cut sets. A listing of the elements in the system, their predecessors, and the probability of successful operation of each element are the inputs. The outputs are the success paths, the cut sets, and a series of upper and lower reliability bounds; these bounds converge to the reliability which would be calculated if all the terms in the model were evaluated. The algorithm for determining the cuts from the success paths is based on Boolean logic and is relatively simple to understand.

COMMENTS: The program listing is contained in the Short Notes section of the May 1971 issue of the journal noted below. Source below also has a number of related programs.

SOURCE: Nelson, Jr., A. C.; et al. (Research Triangle Institute, P.O. Box 12194, Research Triangle Park, North Carolina 27709),: A Computer Program for Approximating System Reliability, IEEE Transactions on Reliability, Vol. R-19, No. 2, May 1970, pp. 61-65.

Contact J. R. Batts of the Research Triangle Institute, telephone (919) 549-8311.

TITLE:	System for Computing Operational Probability Equations (SCOPE)
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360
DATE OPERATIONAL:	July 1969
DESCRIPTION:	This program generates a mathematical expression which equates the reliability of a system as a function of the individual reliabilities of its components. The input to SCOPE describes a system network for various mission-oriented phases of operation. This description must be limited to series-parallel expressions and standby situations are not accepted. Three to four hierarchal levels of complexity are accepted (such as component, stage, system, vehicle). SCOPE generates a complete set of minimal paths from which the system reliability equation is obtained. Output is in the form of punched cards.
COMMENTS:	This program module prepares input to another program, named APRDCT which is also summarized in this catalog. These, and other related programs were developed by the source below.
SOURCE:	These non-proprietary programs were developed under contract by North American Rockwell Space Division, 12214 Lakewood Boulevard, Downey, California 90241, telephone (213) 922-2111. Contact Mike Mezzacapa or C. O. Baker (Director) Design Quality, Reliability and Safety Research, Engineering, and Test.

TITLE: Computer Program for System Reliability

LANGUAGE: FORTRAN IV

COMPUTER: B-5500

DATE OPERATIONAL: 1969

DESCRIPTION: This computer program can be used to analyze the re   ility of
                        the following redundant configurations: parallel, p. .ially
                        redundant (non-identical elements) and standby redundant (non-
                        identical elements). In the first two models (i.e., parallel
                        and partially redundant) it is assumed all the elements have
                        been operating continuously. In the standby redundant configu-
                        rations, elements may be standing by to take over if the
                        primary element fails. The output is such that each block
                        reliability is given in order and system reliability is the
                        last output.

COMMENTS: The method used to calculate system reliability is to consider
                        the system made up of blocks in a series configuration. There
                        is no restriction on the number of blocks in the system. How-
                        ever, at present there is a restriction of six elements in a
                        block. Two input/output formats are available; a freefield
                        data input from a previously prepared disk file, and an on-line
                        interrogation routine.

SOURCE: Niemela, R. J., et al: Computer Program for System Reliability.
                        U. S. Army Electronics Command, Fort Monmouth, New Jersey,
                        March 1970, (AD-706 827).

                        Contact R. J. Niemela, telephone (201) 535-2264.

TITLE:	Reliability Analysis Program
LANGUAGE:	FORTRAN
COMPUTER:	IBM 1130
DATE OPERATIONAL:	August 1968
DESCRIPTION:	The program uses electrical and thermal piece part stress levels to calculate equipment reliability in terms of failure rate and MTBF. Constant individual part data including part reliability grade are stored in the program library file and are coded by part number. A data card is required for each part used in the equipment. This data card lists the indentured item number, part number, operational duty cycle and the applied stress levels. The operational use environment is provided on a single header card. The program has the capability of accepting nodal thermal analysis data from an independent thermal analysis program, or of using measured thermal stress levels for the individual parts, or of using an estimated average thermal stress for all parts within a common assembly. The general equations used for calculating the individual part failure rates are those given in the RADC Reliability Notebook.

Output alternates are: (a) Indentured print out by assembly, module, equipment. A failure rate and MTBF is given for each assembly cumulated for each module and for each equipment. (b) All data in accordance with part number. (c) Grand totals only. (d) Module totals only. (e) Part group totals only.

COMMENTS:	Electronic Communications, Inc., P.O. Box 12248, St. Petersburg, Florida 33733.
SOURCE:	Contact H. Z. Snyder, R. Newbern, or M. Bogart, telephone (813) 347-1121.

TITLE:	Weibull Mission Reliability
LANGUAGE:	FORTRAN
COMPUTER:	IBM 360, GE TIME SHARE MARK II
DATE OPERATIONAL:	June 1969

DESCRIPTION: Mission reliability is computed for a system of independent renewal processes where times - between - renewals are identically Weibull distributed. The program is primarily designed to compute reliability versus system age for a system whose parts exhibit either increasing or decreasing hazard rates. It provides system reliability estimates which reflect the effects of non-Markovian behavior through transient and steady state system ages. The input are simply the Weibull shape and scale parameters for each renewal process in the system. The output is a tabulation of system reliabilities for an array of selected system ages at mission start and selected mission durations.

COMMENTS: Source below has a similar program for Erlangian mission reliability and related programs for fitting data. The government sponsor of these programs was the Army Weapons Command under Contract DAAF03-70-C-0040.

SOURCE: Igor Bazovsky and Associates, Inc., 4419 Van Nuys Blvd., Suite 400, Sherman Oaks, California 91403, telephone (213) 986-3550. Contact Evelyne M. Mutchall, E. Sax, or L. Gran.

TITLE: Mission Reliability Model

LANGUAGE: Basic

COMPUTER: GE 625/635

DATE OPERATIONAL: April 1971

DESCRIPTION: A mission reliability model was developed which permits the
                   criticality of specific subsystems to be identified as related
                   to their impact on the mission performance. The developed
                   model utilizes a simple matrix analysis approach to determine
                   the reliability of the system for any specific mission and
                   operating state. The model determines the product of three
                   matrixes which reflect the unit failure rates, percentage of
                   each unit that is required for its operation in a given state
                   during each phase of a specific mission, and the times associ-
                   ated with each phase of the designated mission. The outputs
                   are: failure rate matrix, time matrix, mission reliability at
                   the completion of each phase, series reliability at the
                   completion of each phase, mission related system MTBF, and
                   series MTBF.

COMMENTS: Source below has a number of computer programs in reliability
                   and in related areas.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland,
                   telephone (301) 296-4626. Contact J. Garafola, D. Githens, or
                   J. Witt.

TITLE:	Reliability/MTBF

TITLE: Reliability/MTBF

LANGUAGE: FORTRAN IV/COMPASS

COMPUTER: CDC 3300 with MASTER System and CDC 3300 with MSOS System

DATE OPERATIONAL: March 1971

DESCRIPTION: The Reliability/MTBF computer program is a multifaceted system reliability program. It calculates upper and lower MTBF estimates at a specified confidence level on a single equipment and also on a sum of observed equipments based on a Chi-square approximation of the assumed exponential failure distribution of the equipment. Point estimate MTBF values are also calculated. Operational data for these calculations may be entered based on a fixed time observation period or on a fixed number of failure observations. These calculations are performed on a multi-system configuration basis. The program also performs an iterative approximation to system reliability at discrete stepped confidence levels (from .00 to .99). This iterative approximation is derived through cumulative sums of Gamma-distributed random numbers which, when summed, produce a random variable that is Chi-square distributed. The system reliability is produced by evaluating the reliabilities of individual equipments in various redundancy orders. The sequence of equipment evaluations continues until the entire reliability structure of the system is evaluated. The program also considers mean repair time which evaluates the system reliability with varying active mission time requirements (for individual equipments).

COMMENTS: Singer-Librascope, 808 Western Avenue, Glendale, California 91201, telephone (213) 245-8711. This program was developed under NUSC contract N00017-71-C-1204.

SOURCE: Contact Gene F. Swygard, or contact Asa Davis, Naval Underwater Systems Center (NUSC), Newport, Rhode Island.

TITLE:	A Program for Estimating Overall System Reliability Based on Component, System and Flight Data (RELY)
LANGUAGE:	FORTRAN IV
COMPUTER:	CDC 6500
DATE OPERATIONAL:	January 1969
DESCRIPTION:	RELY is a program for estimating overall system reliability based upon test and performance data collected at different levels of assembly and at different periods of time. This program requires as input six sets of attribute-type data consisting of three types of data gathered at two distinct time periods. The three types are as follows: (a) component test results, (b) sub-assembly or circuit test results and (c) flight data from test firings of the missile. These data are weighted by sample-size, time, and complexity level and the resulting factors are assumed to be parameters of a beta-distributed reliability function. A Monte-Carlo simulation of the failure events is used to estimate overall system reliability. Output consists of a histogram and a "best" estimate of mean and variance.

COMMENTS:

SOURCE:
T. A. Neef: RELY, A Program for Estimating Overall Systems Reliability Based on Component, System and Flight Data. Picatinny Arsenal, Dover, New Jersey, T. M. 1891, March 1969, 48 pp (AD-684-927).

This program was developed by the Mathematical Analysis Division of the Data Processing Systems Office at Picatinny Arsenal, Dover, New Jersey, telephone (201) 328-3908. Contact B. D. Barnett or T. A. Neef.

TITLE:	Network Reliability Analysis Model
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360/65
DATE OPERATIONAL:	1966
DESCRIPTION:	The model accepts component failure rates and a description of the system to compute system reliability. The method of computation is based on Bayes theorem for conditional probabilities. Outputs are: (a) system reliability, and (b) the partial derivative of system reliability with respect to the reliability of each component (these numbers are used to identify weak points in the system).
COMMENTS:	
SOURCE:	McDonnell Douglas Corporation, 3855 Lakewood Boulevard, Long Beach, California 90801. Contact H. A. Reesing.

TITLE:	Bayesian Confidence Limits for the Reliability of Mixed Exponential and Distribution-Free Cascade Subsystems
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360, UNIVAC 1108
DATE OPERATIONAL:	September 1970
DESCRIPTION:	The posterior cumulative distribution function is derived for the reliability of a system consisting of independent cascade subsystems whose failure density are unknown. A computer program using multiprecision (to any desired level) is operational. Utilizing subsystem test data, it obtains the reliability posterior density in both functional and tabular form, and tabulates the reliability cumulative posterior distribution function for any desired increments, from which Bayesian confidence intervals for system reliability may be obtained. Outputs are: (a) Coefficients and exponents which specify the posterior probability density function of system reliability. (b) Tabulation of $h(R)$ in arbitrary R increments. (c) Tabulation of cumulative posterior distribution function $H(R)$ of system reliability R in arbitrary R increments.
COMMENTS:	
SOURCE:	Industrial Engineering Department, University of Arkansas, Fayetteville, Arkansas 72701, telephone (501) 575-3156. Contact M. D. Springer.

SECTION 6

MAINTAINABILITY PROGRAMS

TITLE: Maintainability Predictions

LANGUAGE: FORTRAN

COMPUTER: IBM 360

DATE OPERATIONAL: November 1970

DESCRIPTION: This program predicts the maintainability (MTTR) character-
                        istics of electronic equipment. It uses procedure 2 of
                        MIL-HDBK 472. Inputs are: line replaceable units, quantity
                        failure rates, individual task times, an assembly level code,
                        a distribution (normal, lognormal or exponential) code and a
                        percentile for max M. The output is per MIL-HDBK 472,
                        procedure 2 worksheet format.

COMMENTS: Source below has a number of computer programs in related areas.

SOURCE: Hughes Aircraft Company, P.O. Box 3310, Fullerton, California
                        92634, telephone (714) 871-3232. Contact A. E. Saari or
                        E. W. Umlauf.

TITLE:	M Demonstration Task Selection
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360
DATE OPERATIONAL:	April 1971
DESCRIPTION:	This program selects maintenance tasks to be applied during the M. demonstration test in accordance with the procedure in Appendix A, MIL-STD 471. The inputs are: line replaceable unit name, quantity, and failure rates; and the number of maintenance tasks. The output is a tabular listing of line replaceable units to be submitted for selection of candidates for the M demonstration test, and the percentage of contribution of each candidate to the total system maintenance load.
COMMENTS:	Source below has a number of computer programs in related areas.
SOURCE:	Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634, telephone (714) 871-3232. Contact A. E. Saair or E. W. Umlauf.

TITLE: Systems Simulation Submodel (SSS)

LANGUAGE: SIMSCRIPT 1.5

COMPUTER: IBM 360/91

DATE OPERATIONAL: 1970

DESCRIPTION: SSS aggregates information pertaining to the reliability and maintainability of aircraft systems and subsystems, and generates distributions of maintenance action rates, times to repair, and numbers and types of maintenance personnel required. After the system personnel and equipment maintenance requirements are established, SSS moves to a simulation phase, using a Monte Carlo technique. This phase generates demands for personnel and equipment to perform maintenance, after a flight, on a given aircraft system, based on the parameter previously developed using statistical techniques. The utilization of personnel and equipment resources in response to the generated demands can be used to develop probability distributions of the span times that reflect the length of time each type of personnel or equipment is employed.

COMMENTS:

SOURCE: Naval Weapon Systems Analysis Office, Marine Corps Air Station, Quantico, Virginia 22134, telephone (202) OX3-2010. Documentation exists for this program.

SECTION 7

SAFETY PROGRAMS

TITLE: Fault Tree Analysis

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/75

DATE OPERATIONAL: 1970

DESCRIPTION: This program provides the means by which a fault tree, already constructed, can be evaluated. The fault tree may be of general complexity, may consist of up to 2000 components and 2000 gates, and may include any number of inhibit conditions. The gate structure of the fault tree is limited to "AND" gates and "OR" gates, and the unique components on the tree are assumed to be independent. The program consists of two distinct sets of computer codes: the PREP codes which obtain the minimal cut sets (failure modes) or the minimal path sets (success modes) of the fault tree and the KITT codes which obtain the numerical probabilities associated with the tree. The input data, besides the fault tree itself, are the component failure rates and repair times. The failure rates may be constant or may vary with respect to phasing. The component failures may have constant repair times, exponential repair distributions, or may be nonrepairable. The repair data may be constant or may vary with respect to phases. Any mixture of various types of component failures can be handled, and further, any inhibit conditions may also be incorporated. The probability characteristics which are obtained include unavailability, reliability, expected number of failures, failure rate, and failure intensity. These characteristics are obtained for the system failure, for each component on the fault tree and for each minimal cut set or path set. The characteristics are obtained at arbitrary time points specified by the user.

COMMENTS:

SOURCE: W. E. Vesely and R. E. Narum: PREP and KITT: Computer Codes for the Automatic Evaluation of a Fault Tree, U.S. Atomic Energy Commission Scientific and Technical Report issued under contract AT (10-1)-1230, Idaho Nuclear Corporation report IN-1349 (TID-4500).

This program has also been adapted for use by the Martin-Marietta Corporation, Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

TITLE: Flight Safety

LANGUAGE: COBOL

COMPUTER: UNIVAC 1108, adapted to IBM 360

DATE OPERATIONAL: 1970

DESCRIPTION: Thirteen programs are combined in three evaluation techniques
                   to produce a quantified safety index of malfunction-problem
                   severity. The first of these techniques yields a mathematical
                   model that accepts inputs taken from pilot post-flight debrief-
                   ings. The second permits systematic identification of the
                   functional relationships of aircraft equipment to flignt safety.
                   The third provides functional safety sensitivity indices
                   corresponding to malfunction information from the post-flight
                   debriefings.

                   Taken together, the three techniques yield a methodology sensitive
                   to the probability of occurrence of an in-flight malfunction and
                   the probability that it will result in accident exposure. Each
                   of the techniques will yield safety criticality indices. That is,
                   three independent sets of indices -- two applicable to pilot-
                   reported symptoms during flight, and one applicable to equipment
                   malfunctions -- can be compiled. The responsiveness to current
                   operations makes this method unique in its ability to currently
                   and continuously rank malfunction problems with respect to their
                   accident potential. This ranking, based on criticality assess-
                   ment, can provide the basic parameters necessary for analysis of
                   safety versus cost for proposed aircraft modifications, changes in
                   maintenance or flight operations, or even alternative aircraft
                   designs.

COMMENTS:

SOURCE: ARINC Research Corporation, 1222 East Normandy Place, Santa Ana,
                   California 92702, telephone (714) 547-7594. Contact J. G. Fountain
                   or Douglas Kelly.

TITLE: Fault Tree Analysis

LANGUAGE:

COMPUTER:

DATE OPERATIONAL:

DESCRIPTION: This program is directed at the requirements of MIL-S-38130A for
                   quantitative system safety analyses. It calculates fault tree
                   critical path and system probability statistics using Monte Carlo
                   simulation with importance sampling.

COMMENTS: Source below has several different but related programs concerned
                   with fault tree analysis. These include programs which produce
                   plotter tape to automatically produce fault tree diagrams for
                   routine customer documentation.

SOURCE: Boeing Computer Services, Inc., P.O. Box 24346, Seattle,
                   Washington 98124. Contact C. S. Bartholomew.

TITLE: Simulated Analysis of Shipboard Electronics

LANGUAGE: FORTRAN IV

COMPUTER: IBM 7094 or compatible computer

DATE OPERATIONAL:

DESCRIPTION: The simulation model determines safety, readiness, reliability,
                   maintainability and availability parameters of the shipboard
                   electronic system based on Monte Carlo techniques. Each mission
                   is composed of several phases with each phase composed of events
                   (general quarters, etc.). All events of the mission are
                   simulated. When the mission is complete, the result from the
                   simulation in terms of major item, subsystems, systems and
                   functional reliability, maintainability, availability, and
                   safety parameters are determined. In addition, the total number
                   of failures encountered and the maintenance man-hours are available.
                   The simulation uses an "event slicing" approach similar to the
                   General Purpose System Simulator and Simscript Programming
                   Languages. The mission simulation synthesizes the occurrence of
                   scheduled and unscheduled events. The scheduled events are those
                   events which compose the entire mission.

COMMENTS: The inclusion of operational type along with safety parameters
                   broadens the scope of this program.

SOURCE: Eliot, C. C. and Briggs, R. (Raytheon Company, Missile Systems
                   Division, Bedford, Massachusetts): Analysis of Shipboard
                   Electronics Using Simulation Techniques. Proceedings Eighth
                   Reliability and Maintainability Conference, Denver, Colorado,
                   July 7, 8, 9, 1969, pp. 403-416.

SECTION 8

HUMAN FACTORS PROGRAMS

TITLE: System Response Time Simulator (SRTS)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65, CDC 6600

DATE OPERATIONAL: June 1969

DESCRIPTION: This is a user-oriented program specifically designed for
                    simulation of complex multi-station man-machine systems, such
                    as Combat Information Centers. The major design goal of the
                    SRTS is to predict system response time to threat situations
                    under varying load or saturation conditions. The required inputs
                    include the threat scenario in Operational Sequence Diagram (OSD)
                    format; time curves for each man and machine action; the physical
                    arrangement of men and equipment; and the system communication
                    matrix. Overall system response time is determined by summation
                    of Monte Carlo sampling of the time curves. The user can also
                    time any specific subsequence of the system. Each threat can be
                    simulated singularly or in conjunction with other on-going threats,
                    testing system performance under varying load conditions. Each
                    simulation can be replicated as many times as desired, giving
                    estimates of minimum, maximum and average response times.

                    For each system replication the user receives an event by event
                    listing time of occurrence, performing station and action
                    performed. This simulation log also flags all system delays and
                    communication failures. All clock times are printed out and
                    at the end of the simulation summary statistics are given for
                    each clock. An optional output of each simulation is a CalComp
                    plot of the time line events depicted in the OSD.

COMMENTS: The SRTS has been used in the DLGN-38, CVAN-71, and DLG/DLGN
                    programs. It is scheduled for use in Naval Ships Engineering
                    Center's command control standardization program.

SOURCE: Naval Electronics Laboratory Center, San Diego, California 92152.
                    Contact Dr. R. A. Fleming, Human Factors Technology Division
                    (Code 3400), telephone (714) 225-7372, Autovon 952-7372.

TITLE: Maintenance Index Computing Program

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65

DATE OPERATIONAL: 1970

DESCRIPTION: This is a computer program that calculates aircraft maintenance
                      manhour requirements. It facilitates the rapid, consistent and
                      valid calculation of mature direct maintenance manhour require-
                      ments for any aircraft for which basic description and perform-
                      ance parameters are available, while the aircraft is operated
                      at selected but varied mission requirements. The program prints
                      maintenance manhours required for the specified condition cate-
                      gorized for each system's work unit code at the five levels of
                      organizational and intermediate maintenance.

COMMENTS: This same source has other, related programs which are modular-
                      ized toward various needs for information such as: Source Model
                      (operational capability analysis), Maintenance Break Rate Program,
                      Maintenance Regeneration Program, Direct and Indirect Maintenance
                      Manpower Program, Maintenance and Support Manning Program, Replen-
                      ishment Spares Cost Model, and Computerized AGE Requirements
                      Program.

SOURCE: Northrop Corporation, Aircraft Division, 3901 West Broadway,
                      Hawthorne, California 90250, telephone (213) 675-4611. Contact
                      D. D. Gregor.

TITLE: SHIP II

LANGUAGE: FORTRAN IV

COMPUTER: CDC 3800

DATE OPERATIONAL: 1968

DESCRIPTION: SHIP II simulates the operations of an entire destroyer class
                  ship, or part of a ship. Emphasis is placed on those aspects
                  of operations affecting and affected by manpower considerations.
                  Model output statistics include: (a) manhours spent on watch,
                  maintenance, ships work, training, etc. (by man, division, total
                  ship), (b) amount of work and maintenance left undone, (c)
                  equipment status, (d) training and combat readiness evaluation,
                  and (e) many other data categories related to personnel and
                  equipment utilization. All functions involving manpower are
                  simulated. Statistics can be generated for any time interval.
                  A scenario which includes evolution and training requirements
                  drives the model. The model is viewed as a useful tool for
                  manpower planners concerned with both new and existing ships and
                  systems.

COMMENTS: This program appears to be useful for equipment studies as well
                  as for personnel studies.

SOURCE: Naval Personnel Research and Development Laboratory (Code 200),
                  Washington Navy Yard, Washington, D.C. 20390, telephone
                  OX 3-2664.

SECTION 9

OPTIMIZATION PROGRAMS

TITLE: Optimization of Redundancy Subject to Constraints (SYEFF)

LANGUAGE: FORTRAN V

COMPUTER: UNIVAC-1108

DATE OPERATIONAL: 1965

DESCRIPTION: This system is designed to perform system reliability optimiza-
                  tion and tradeoff subject to constraints of weight, volume, and
                  cost. The optimization is accomplished by an iterative process
                  in which the program selects which functional element of the
                  system, if made redundant, would result in the largest reliability
                  increase for leasc penalty in weight, volume, and cost. This
                  element is added to the basic configuration and the process is
                  repeated until either a maximum constraint is reached or the
                  system cost goes through a minimum inflection point. Various
                  outputs are provided for each state solution which includes cumula-
                  tive weight and volume, total cost, total R&D cost, total opeara-
                  tional cost, expected number of systems required to meet a mission
                  requirement reliability, and system mean life. Additionally, the
                  program takes the UNIVAC 1108 data and provides a plot to a SC4020
                  microfilm recorder, which produces a plot ouptut in terms of
                  reliability versus time, reliability sensitivity to incremental
                  weight, and, if cost data are included, expected cost versus
                  weight, and cost versus design life.

COMMENTS: Source below has in its scientific computational library a series
                  of computer programs to perform system effectiveness and related
                  engineering analysis.

SOURCE: Lockheed Missiles and Space Company. Sunt vale, California, tele-
                  phone (408) 743-2486. Contact R. L   ~ay or W. L. Finch.

TITLE: Provisioning Model for General-Purpose Use by the Aviation
                    Supply Office

LANGUAGE: FORTRAN, COBOL, SPURT

COMPUTER: UNIVAC-490, 494

DATE OPERATIONAL: April 1970

DESCRIPTION: The spares-optimization model provides a method of obtaining an
                    optimum inventory of spare parts at minimum cost. There are two
                    program-cutoff constraints: (a) cost, i.e., the program will
                    stop purchasing spares when a particular cost constraint is
                    reached, and (b) the probability of spares adequacy obtained by
                    minimizing expected stock back orders. Optimization is accom-
                    plished by applying an iterative process, which uses the Poisson
                    distribution. The output of the probability-constrained
                    optimization program is an Initial Outfitting List (IOL) and
                    quantities of system stocks (backup stocks). The IOL indicates
                    the quantities of items to be made available at the time of
                    initial outfitting and to be maintained at a specified activity.
                    These items keep the activity in a material-readiness condition.
                    The system-stocks quantity calculated for each item is the quan-
                    tity of the item to be maintained at a backup spares location,
                    called the "systems stockage point." This location supports all
                    bases, providing spares for items lost because of wearout and for
                    certain types of items that are being repaired. The output is
                    the gross spare parts requirement for a specified distribution
                    of support points as determined by operating plans. The actual
                    level of spares adequacy versus that desired for each base
                    selected is summarized, as is cost.

COMMENTS: This program was developed under Naval Air Systems Command
                    contract N000 19-70-C-0027. Source below has a number of related
                    programs.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland
                    21401, telephone (301) 268-4100. Contact Fred Jacoby.

TITLE: A Method for Automatically Selecting Optimum Redundancy

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6500

DATE OPERATIONAL: November 1969

DESCRIPTION: A recently developed computer program, H744, aids in selecting
                    redundant parts and their redundancy type. The program determines
                    the impact of active, standby, and storage redundancy for each
                    component on various system characteristics such as: (a)
                    probability of no system loss, (b) total number of system failures,
                    (c) maintenance time, (d) weight, (e) volume, and (f) recurring
                    cost. The program is uniqu. .y assessing the reliability penalties
                    associated with each type ﹍ redundancy. With active redundancy,
                    the failure probability of some failure modes (e.g. external valve
                    leakage) is increased. Standby redundancy requires additional
                    switching equipment and storage redundancy necessitates various
                    isolation equipment to effect a replacement.

                    The program input utilizes component characteristics such as
                    failure rates, failure modes, environmental stress factors,
                    maintenance times, weights, volumes, and cost. Certain system
                    or mission charatteristics are also used as input and include
                    operating times, non-operating times, and number of initial
                    components. The program output is a preferential ranking of
                    redundant components and their redundancy types based on a pre-
                    determined selection criterion.

COMMENTS:

SOURCE: McDonnel Douglas Astronautics Company, Huntington Beach, California,
                    telephone (714) 896-4648. Contact W. H. Widawsky.

81

TITLE: Dynamic Programming for Equipment Replacement (DPER)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/50

DATE OPERATIONAL: January 1971

DESCRIPTION: This model determines the optimum cycle time for equipment replace-
                        ment when the replacement equipment is identical to the original.
                        The replacement period is dependent upon acquisition cost and the
                        cost or return per unit of use.

COMMENTS:

SOURCE: Naval Seabee Systems Engineering Office (Code 15B), Port Hueneme,
                        California 93043, telephone (805) 982-4942, Autovon 898-3300 X4942.

TITLE: Reliability Versus Cost Model

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65

DATE OPERATIONAL: 1969

DESCRIPTION: This program uses dynamic programming techniques to determine the
                     maximum system reliability attainable as a function of a specific
                     cost investment for improved parts. It has been used as a design
                     guide to develop the optimum mix of standard and high-reliability
                     parts in critical electronic systems. The outputs are: (a) Curve
                     of reliability versus dollars ⁻ ?lable for improved parts. (b)
                     A list of the parts that shoulo ₋₋ 'nproved (and the required
                     level of improvement) to achieve a given reliability. (c) A list
                     of the parts that should be improved to maximize system reliability
                     under specific cost constraints.

COMMENTS:

SOURCE: McDonnell Douglas Corporation, 3855 Lakewood Boulevard, Long
                     Beach, California 90801. Contact H. A. Reesing.

SECTION 10

ALLOCATION PROGRAMS

TITLE: S-II Prediction-Apportionment Program (APRDCT)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360

DATE OPERATIONAL: July 1969

DESCRIPTION: This is a general reliability prediction and approtionment program
                    which allocates contractural reliability goals to lower levels
                    based upon indices developed for each mission phase. These
                    indices are also used to predict reliability from lower to higher
                    levels of system organization. The weighting indices are based
                    upon a combination of the input parameters, which are failure-
                    rates, mission durations and system contractural stage goals,
                    and the input functions which are the system reliability equation
                    and the mission-phase ranking matrix. Output is a tabular listing
                    of components along with the predicted or apportioned reliability
                    by mission-pnase and by subsystem, etc.

COMMENTS: This program module accepts inputs from two other programs
                    developed by the same source. The system reliability equation
                    is generated by SCOPE and the mission-phase ranking matrix is
                    developed by a Thurstone-Mosteller program. SCOPE is summarized
                    in this catalog. Tne Thurstone-Mosteller program is a rating
                    system which computes weighted reliability ranking from paired
                    comparison ranking surveys.

SOURCE: These non-proprietary programs were developed under contract by
                    North American Rockwell, Space Division, 12214 Lakewood Boulevard,
                    Downey, California 90241, telephone (213) 922-2111. Contact Mike
                    Mezzacapa or C. O. Baker (Director), Design Quality, Reliability
                    and Safety Research, Engineering and Test.

TITLE: Generalized Electronic Maintenance Model (GEMM)

LANGUAGE: FORTRAN IV

COMPUTER: B 5500, IBM 360, CDC 6600

DATE OPERATIONAL: July 1971

DESCRIPTION: GEMM is a life-cycle, cost-effectiveness model for logistics trade-offs and maintainability-reliability trade-offs. It is capable of determining the optimum maintenance allocation for a given system based on life-cycle costs. It is also capable of examining one maintenance policy in terms of life-cycle costs and operational availability, maintenance allocation, test equipment and manpower requirements and initial provisioning data. Also, graphical and tabular results of sensitivity analysis are obtained.

COMMENTS:

SOURCE: Systems Analysis Division, Plans and Analysis Directorate, Army Electronics Command, Fort Monmouth, New Jersey 07703, telephone (201) 535-2113, Autovon 99-52113. Contact D. A. Tyburski.

TITLE: Reliability and Maintainability Improvement Priority Assignment
                     Program

LANGUAGE: Basic

COMPUTER: GE 625/635

DATE OPERATIONAL: July 1971

DESCRIPTION: A series of programs have been developed which permit priorities
                     for $\underline{R}$ and $\underline{M}$ improvements of alternative systems and subsystems
                     to be assigned on the basis of an optimum strategy. The technique
                     determines the seniority of the total system availability to the
                     $\underline{R}$ and $\underline{M}$ improvements to candidate subsystems which may be common
                     to several systems. From the resultant availability improvement
                     to each of the common systems weighted by the number of each type
                     of common system and the system's remaining life a value index is
                     determined. The slope of the value index improvement rate is then
                     identified and used as a basis for identifying the optimum strategy.
                     Improvement goals for each subsystem are defined by improving each
                     to the point where the next system in the ordered list of value
                     indexes has a higher slope. The outputs are: (a) system/subsystem
                     cycle and steady state availabilities under current status, (b)
                     system/subsystem cycle and steady state availability improvement
                     as a function of $\underline{R}$ or $\underline{M}$ improvements, (c) subsystem value indexes
                     as a function of $\underline{R}$ or $\underline{M}$ improvements, and (d) slope of value
                     indexes as a function of $\underline{R}$ or $\underline{M}$ improvements.

COMMENTS: Source below has a number of related programs.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland
                     21401, telephone (301) 295-4626. Contact J. Garafola, D. Githens,
                     or J. Witt.

TITLE: Maintainability Allocation Techniques

LANGUAGE: Extended Basic

COMPUTER: GE 265

DATE OPERATIONAL: July 1969

DESCRIPTION: The purpose of this program is to allocate MTTR to individual units or equipments of a system, based on complexity factors. Inputs are unit/group failure rates, complexity factors, and system target MTTR. The output is a tabular listing of unit/group with allocated MTTR's.

COMMENTS: Source below has a number of related programs.

SOURCE: Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634, telephone (714) 871-3232. Contact E. W. Umlauf or A. E. Saari.

SECTION 11

DATA PROGRAMS

TITLE:	Time Series Data Analysis

LANGUAGE: FORTRAN

COMPUTER: IBM 360, GE time share Mark II

DATE OPERATIONAL: June 1969

DESCRIPTION: Times between identical events are computed from time series data for individual items having a given configuration. Weibull and Gamma probability laws are fitted to the times between identical events for the individual items and for the configuration (pooling individual item data). The purposes of the program are: (a) to evaluate age trends of times between events for the individual items, (b) to evaluate differences of times between events from one item to another having the same configuration, (c) to evaluate best-fit Weibull and Gamma shape and scale parameters for use as inputs to an interval reliability program. The Gamma fitting is done using the method of matching moments while the Weibull is fitted by the method of least squares which allows for censored observations.

The output identifies the program title, the configuration and the event effect category (e.g., failure or degradation, etc.). For each effect category the various events within the category are identified. For each event identified, the individual items are identified. For each individual item, a table of item ages and times between events for these ages is printed. For each table, the fitted parameters for Weibull and Gamma laws are printed (mean, standard deviation, shape, scale). If a censored observation exists, its value is printed. After the individual item output, the event effect and event are again identified and best fit parameters are printed for all configuration data and the given event.

COMMENTS: Source below has related programs for fitting data. The government sponsor of these programs is the Army Weapons Command under contract DAAF03-70-C-0040.

SOURCE: Igor Bazovsky and Associates, Inc., 4419 Van Nuys Boulevard. Suite 400, Sherman Oaks, California 91403, telephone (213) 986-3550. Contact E. M. Mitchell, G. Benz, or L. Gran.

TITLE: Failure Rate Data Program (FARADA)

LANGUAGE: FORTRAN, COBAL and FMSAEG Special

COMPUTER: UNIVAC 1108 with remote terminals

DATE OPERATIONAL: 1968

DESCRIPTION: These programs are for summarizing, integrating and analyzing reliability field experience data. The outputs are statistically presented failure rate and failure mode data prepared from EDP listings and presented in photo-reproduced handbook format.

COMMENTS: Associated publications include FARADA handbooks, instruction book, and special analyzed data reports. Also a quarterly updated computer tapes of handbook data are available on loadn.

SOURCE: FARADA Information Center, Naval Fleet Missile Systems Analysis and Evaluation Group (FMSAEG), (Code 8621), Corona, California 91720, telephone (714) 736-4677. Contact E. T. Richards.

TITLE: Reliability Data Storage/Retrieval Program

LANGUAGE: FORTRAN

COMPUTER: IBM 360/40

DATE OPERATIONAL: September 1970

DESCRIPTION: Solar currently operates an electronic data processing system developed to store reliability/maintainability related data for subsequent rapid and selective retrieval. The program will provide most of the data base for analyses such as life cycle cost, integrated logistics support, reliability/maintainability, etc., but does not perform these tasks automatically. The program can also be used to monitor the failure occurrence/corrective action process on a development project. Selective data retrieval may be by part number, sub-system number, unit serial number, project number, and others. Two output formats are available. The block format contains all the elements of the data base and the other printout is an abstract from the same data base.

COMMENTS:

SOURCE: Solar Division, International Harvester Company, 2200 Pacific Highway, San Diego, California 92112, telephone (714) 233-8241. Contact L. L. Novak or B. M. Gallagher.

SECTION 12

VULNERABILITY PROGRAMS

TITLE: Assessing Surface Ship Vulnerability (ASSV)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 7090/7094

DATE OPERATIONAL: Believe 1970

DESCRIPTION: A computer program is presented for deriving probabilities of achieving prescribed levels of operational impairment to integrated ship systems as a consequence of possible weapon attacks. The computer solution is based on a Monte Carlo (random draw) technique wherein a high-speed computer generates many random events from which the probability of specific occurrences is then determined. The program essentially takes single-event probabilities of inactivating various possible combinations of system components and derives multiple-event probabilities of inactivating critical combinations associated with prescribed levels of operational impairment. This program can be used to assess vulnerability of any type of ship to any type of weapon attack where the interaction of weapons and ship components can be represented by a single-event probability matrix.

COMMENTS: Program listing is in the reference given below.

SOURCE: R. M. Santamaria: Naval Ship Research and Development Center, Washington, D.C. 20034, A Computer Program for Assessing Surface Ship Vulnerability (ASSV), Report Number NSRDC-2289, December 1970, 63p. (AD-880 285L).

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TITLE: Ship Damage Probability Program

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6400

DATE OPERATIONAL: December 1970

DESCRIPTION: This Monte Carlo program describes single- and multiple-hit
                  internal blast damage to ship targets. Inputs are warhead
                  flight path (azimuth, elevation, velocity, aim point, CEP) and
                  explosive weight in warhead (pounds TNT equivalent). This
                  program can also calculate damage probabilities for uniformly-
                  distributed internal blast rather than aim point-CEP combination.
                  Damage outputs include probabilities of loss of seaworthiness,
                  missile firepower, and mobility and probability of mass detona-
                  tion, all as a function of number of hits (up to five). A
                  so-called second generation program has been developed, but
                  this has not been converted for use on the CDC. It considers
                  a wider variety of hit conditions, and is not limited to
                  internal blast.

COMMENTS:

SOURCE: Naval Ordnance Laboratory (Code 101), White Oak, Silver Spring,
                  Maryland 20910.

SECTION 13

ELECTROMAGNETIC COMPATIBILITY

TITLE: Shipboard Electromagnetic Compatibility Analysis (SEMCA)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6700, IBM 360

DATE OPERATIONAL:

DESCRIPTION: SEMCA is an electromagnetic compatibility prediction program
                    designed to calculate and catalog characteristics of all emissions
                    of r-f energy in an isolated environment, and to determine all
                    potential interference sources which can cause interference at
                    each receiver from the total r-f environment. The program is
                    used to process transmitter spectrums through the transmitter
                    channel components, free space, receiver channel components,
                    and the mixer i-f sections of the receiver, and then to predict
                    the spectrum at the output of the last receiver i-f filter.

COMMENTS: There are three versions of this program: SEMCA I, II, and III.
                    The development of these programs has spanned several years.

SOURCE: SEMCA was prepared for the Naval Ship Engineering Center (Code
                    6179C), Hyattsville, Maryland 20782.

                    SEMCA III, Volume VIIA, User's Reference Manual, January 1970
                    (AD-869 295L).

TITLE: General Shielding Effectiveness

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: Believe 1968

DESCRIPTION: This is a computer program for the shielding effectiveness
                    equations for the problem of electromagnetic shielding,
                    applicable within the near field. The principles used in this
                    program have been used historically in the analysis and synthesis
                    of electromagnetic shields. The principal uses of this technique
                    would be: (a) to evaluate theoretical shielding effectiveness
                    for comparison to carefully-obtained test data taken under
                    controlled conditions, (b) to obtain approximate values of
                    shielding effectiveness for some less-controlled set of conditions
                    encountered in practice, and (c) to enable rapid evaluation of
                    the effect of specific parameters upon shielding effectiveness.
                    This program is very simple to use. Material properties data
                    and incident-wave impedance data are placed on data cards, to-
                    gether with the shield thickness and the frequency. The
                    computer printout shows all inputs plus corresponding outputs.
                    Outputs consist of: the absorption loss, both reflection losses,
                    the re-reflection correction term and the total shielding
                    effectiveness, all of which are expressed in db.

COMMENTS: The program listing is in the reference given below. This
                    symposium record (annually) is a source of information about
                    electromagnetic compatibility computer programs.

SOURCE: Adams, W. A. (Martin Marietta Corporation, Denver, Colorado) and
                    Mills, A. H. (General Dynamics Convair, San Diego, California):
                    Electromagnetic Shielding in the Near Field. Electromagnetic
                    Compatibility Symposium Record, Seattle, Washington, July 23,
                    24, 25, 1968, pp. 317-329.

TITLE: Intra-Vehicle Electromagnetic Compatibility Analysis

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: Believe 1971

DESCRIPTION: A computer program was developed to predict and analyze electro-
                  magnetic interference between avionics systems on aerospace
                  vehicles. It is an analytic tool to aid the user in establishing
                  intra-vehicle electromagnetic compatibility. The program is used
                  to derive information which is otherwise impractical or difficult
                  to obtain. A study of physical principles, previous work, and
                  practical experience identified four predominant interference
                  coupling paths: antenna-to-antenna, wire-to-wire, electromagnetic
                  field (antenna)-to-wire, and box-to-box. Basic questions and
                  analysis techniques were formulated for each coupling path. These
                  were then assembled into four practical computer analysis programs.
                  The programs are modular and thus can be run separately or combined
                  into one integral program. The report noted below contains a
                  complete description of each program including the mathematical
                  models, basic equations, and analysis procedures used. Examples
                  of the application of the programs together with sample computer
                  outputs are presented.

COMMENTS: This program was sponsored by the Air Force under contract
                  F33615-70-C-1333.

SOURCE: J. L. Bogdanor, et al.: Intra-Vehicle Electromagnetic
                  Compatibility Analysis, Part I., TR-71-155-PT-1, July 1971, 89p.
                  (AD-886 470).

APPENDIX A

CROSS-INDEX

Acronyms (Program Titles):

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